LOW COST, ULTRA-HIGH THROUHPUT PARTICLE COUNTING USING INERTIAL MICROFLUIDICS

B. Çetin[1], H. Kaplan[2], G. Durkaya[2] and H. Kurtuldu[3]

[1]Microfluidics & Lab-on-a-chip Research Group, İ.D. Bilkent Uni., Ankara, Turkey

[2]Nanoscopy Laboratory, Dept. Metal. Materials Eng., Atılım University, Ankara, Turkey

[3]Biomedical Engineering, Baskent University, Ankara 06810 Turkey

ABSTRACT

In this work, an ultra-high throughput microfluidic particle counting system is demonstrated. For the particle counting, a low cost custom-design optical hardware is developed. The microfluidic chip utilizes the inertial microfluidics to focus the particles in a certain location which significantly enhanced the optical signal utilized for the quantification of the number concentration. The effect of the particle focusing on the counting performance is demonstrated. The proposed system has a potential to be portable and has a capability to process 10 ml of sample within couple minutes.

KEYWORDS: Inertial microfluidics, Particle counting, Fluorescence microscopy

INTRODUCTION

Particle counting is one of the important and key processes regarding the biotechnological and biomedical applications[1]. Although an accurate enumeration of target bio-particles (with low number concentration) is desired in many applications, there are also many application in which the counting of high number of particles is desired such as red blood cell counting, somatic cell and bacterial counting in whole milk[2].

THEORY

Typically, the Reynolds number in conventional microfluidic applications is in the order of 10^{-2}-1.0 which dictates Stoke's flow and streamlines parallel to the channel walls. However, when the Reynolds number reaches 10-50, some secondary flows begin to occur within the channel which induces lift drag and forces on the particles flowing in the channel. The balance of these forces dictates motion of particles at some certain locations (both in the lateral and height direction)[3]. These applications are known as inertial microfluidics. This focusing effect is more pronounced if the flow is within a curved channel. In this work, this focusing nature of the inertial microfluidics is utilized to amplify the optical signal for particle counting.

EXPERIMENTAL

The fabrication of the molds are performed by high-precision machining. Two channels, one is straight (H:200μm, W:750μm) and one is spiral (H:600μm, W:70μm) with 5 runs are fabricated. The experimental setup consists of a laboratory syringe pump (New Era Pump Systems-NE 300), syringes and tubing. A buffer solution in which 10μm fluorescent (Distrilab Fluoro-Max) particles are suspended in a deionized (DI) water solution. Particle solution with different concentrations are used in the experiments. The whole system together with the custom-design optical system are shown in Figure 1. As delineated in Figure 1-(B), a custom-made camera-based microfluidic cytometer is built for optical determination of particle concentration in flow. The fluorescent counting system employs a 4X (0.1 NA) objective lens to view the microchannel from below. Excitation, emission and dichroic filters are selected based on the spectral characteristics of green fluorescent particles (excitation and emission peak at 468 nm and 508 nm, respectively). A narrow band LED is used as a source for excitation. A low-cost CMOS board camera (Imaging source GmbH) is utilized to measure fluorescent intensity captures images at every 1 s with 0.25 s exposure time, providing sufficient enough intensity for measurements at low particle concentrations. The optical magnification is adjusted to visualize the entire channel width with the projected pixel size of 1.15 μm on the camera sensor. A motorized stage (Psaron HTI) is integrated into the system to perform axial-scan over the channel height with 1.3 μm resolution. Image data from the axial-scan is used to find the hydrodynamic depth of focus.

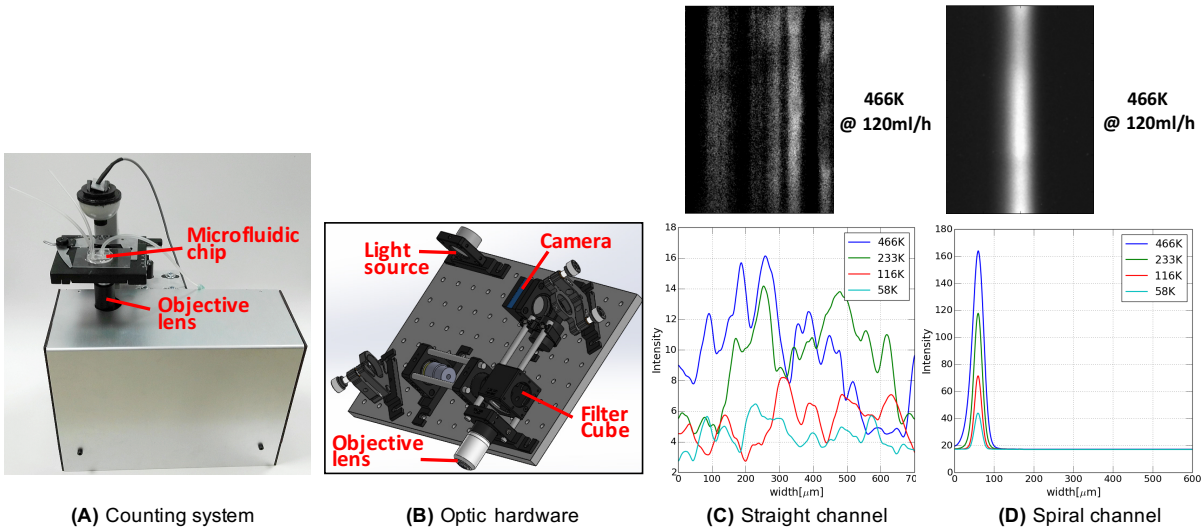

Figure 1: Hardware of the system and the experimental results.

RESULTS AND DISCUSSION

The images acquired at a fixed flow rate of 120 ml/h are first averaged over the flow direction in order to obtain the fluorescent intensity as a function of distance over the channel width. The acquisition time is 20 s during which 670 µl volume of fluid is analyzed. During this short period of time, as shown in Figure 1-(D), the intensity profile of focused particles on the spiral channel is greatly influenced by the particle concentration. As depicted from the figure, as the concentration increases, the change in the peak intensity per thousand particles is between 0.12 and 0.67%. On the other hand, on the straight channel without the focusing effect the intensity profiles for different number of particles are indistinguishable from each other. The intensity profile also shows the focusing effect of the spiral channel.

CONCLUSION

The determination of the particle concentration is obtained for 10µm successfully with ultra high-throughput. The extension of this study will be the generating experimental results at different flow rates together with 2µm particles. 2µm particles represents the bacteria and 10µm particles resembles the somatic cells. Therefore, ultimate goal of this project is to utilize this system to determine the bacterial load and somatic cell count of the whole milk with a counting precision and accuracy less than 3% and 10%, respectively. These values represents the capabilities of the counters currently available in the market, measuring only up to 10-20 µl of the sample one at a time.

ACKNOWLEDGEMENTS

Financial support from the Turkish Scientific and Technical Research Council (Grant No. 114M597) is greatly appreciated.

REFERENCES

[1] B. Cetin, M. B. Ozer, M. B., M. E. Solmaz, “Microfluidic bio-particle manipulation for biotechnology,” *Biochem. Eng. J.,* 92, 63-82, 2014.

[2] Moon, J. S., et al. "Application of a new portable microscopic somatic cell counter with disposable plastic chip for milk analysis." Journal of Dairy Science, 90, 2253-2259, 2007.

[3] J. Zhang, S. Yan, D. Yuan, G. Alici, N.-T. Nguyen, M. E. Warkiani, W. Li, “Fundamentals and applications of inertial microfluidics: a review,” *Lab Chip.,* 16, 10-34, 2016.

CONTACT

* B. Cetin; phone: +90-312-290-2108; barbaros.cetin@bilkent.edu.tr

From: authors@microtas2016.org
Subject: MicroTAS 2016: Author Acceptance 5078 Confirmation
Date: August 11, 2016 at 01:32
To: barbaros.cetin@bilkent.edu.tr

Dear MEMS 2016 Late News Presenter,

This confirms that you have accepted the invitation to present your Late News paper at the 20th International Conference on Miniaturized Systems for Chemistry and Life Sciences (MicroTAS) that will take place 9-13 October 2016, at the Convention Center Dublin, and that you are the presenting author of this paper.

Below is the information you provided. Look this over carefully to ensure that everything is correct and that there are no spelling errors or typos. If you do find any errors, please go back to the acceptance page and correct.

Please remember that you have agreed to be the presenting author for your presentation and understand the following:

- On behalf of all institutions represented on this paper, I have accepted the invitation to present this paper at the MicroTAS 2016 Conference.

- I will notify all authors of the 9 October 2016 publication date and complete all patents by this date.

- In the event that I may be unable to attend MicroTAS 2016 for any reason, it is my responsibility to ensure that this paper is presented at the Conference by one of my co-authors.

- I have notified my organization of the financial responsibilities associated with accepting this invitation to present this paper including the registration fee and all travel expenses to Dublin, IRELAND.

- My organization has given me permission to attend this Conference.

- I will also adhere to the deadlines set forth for my presentation, including submitting the copyright form, registering for the Conference by Monday 15 August 2016, and attending the Conference, 9-13 October 2016.

If you should have any questions regarding your acceptance, please contact us at authors@microtas2016.org.

On 2016-08-10 at 18:31:56, the following information was submitted:

Reference_Number = 5078
Region = Europe_Africa
Institution = University
Salutation = Prof.
First_Name = Barbaros
Last_Name = Cetin
Degree = Ph.D.
Position = Asst. Prof. Dr.
Organization = Bilkent University
Department = Mech. Eng.
Division =
Address = Bilkent University EA124
City = Ankara
State =
ZIP_Code = 06800
Country = TURKEY
Phone = +90-312-290-2108
Mobile =
Fax =
Email = barbaros.cetin@bilkent.edu.tr
Advisor_Principal = No
Advisor_Principal_Name =
Advisor_Principal_Email =
Student_Award =
Format = Poster
Paper_Title = LOW COST, ULTRA-HIGH THROUHPUT PARTICLE COUNTING USING INERTIAL MICROFLUIDICS
Word_Count =
F_M_Initial_1 = B.
Last_Name_1 = Cetin
Email_1 = barbaros.cetin@bilkent.edu.tr
Affiliation_1 = Bilkent University
Country_1 = TURKEY

F_M_Initial_2 = H.
Last_Name_2 = Kaplan
Email_2 = hakankaplan89@gmail.com
Affiliation_2 = Atilim University
Country_2 = TURKEY
F_M_Initial_3 = G.
Last_Name_3 = Durkaya
Email_3 = goksel.durkaya@atilim.edu.tr
Affiliation_3 = Atilim University
Country_3 = TURKEY
F_M_Initial_4 = H.
Last_Name_4 = Kurtuldu
Email_4 = hkurtuldu@baskent.edu.tr
Affiliation_4 = Baskent University
Country_4 = TURKEY
F_M_Initial_5 =
Last_Name_5 =
Email_5 =
Affiliation_5 =
Country_5 =
F_M_Initial_6 =
Last_Name_6 =
Email_6 =
Affiliation_6 =
Country_6 =
F_M_Initial_7 =
Last_Name_7 =
Email_7 =
Affiliation_7 =
Country_7 =
F_M_Initial_8 =
Last_Name_8 =
Email_8 =
Affiliation_8 =
Country_8 =
F_M_Initial_9 =
Last_Name_9 =
Email_9 =
Affiliation_9 =
Country_9 =
F_M_Initial_10 =
Last_Name_10 =
Email_10 =
Affiliation_10 =
Country_10 =
F_M_Initial_11 =
Last_Name_11 =
Email_11 =
Affiliation_11 =
Country_11 =
F_M_Initial_12 =
Last_Name_12 =
Email_12 =
Affiliation_12 =
Country_12 =
Additional_Authors =
Modified = Yes
Uploaded = Yes
Cancelled = No
Acceptance = Accept
Keyword_1 = Inertial Microfluidics
Keyword_2 = Particle Counting
Keyword_3 = Ultra-High Throughput
Keyword_4 =
Keyword_Comments =

Bilkent Üniversitesi

Sayı :88346758.0.00.00.00/231-1875/ 02.09.2016
Konu : Yrd. Doç. Dr. Barbaros ÇETİN hk.

TÜRKİYE BİLİMSEL VE TEKNOLOJİK ARAŞTIRMA KURUMU BAŞKANLIĞI'NA,
ANKARA

13804848860 T.C. numaralı Yrd. Doç. Dr. Barbaros ÇETİN, 09.10.2016 – 13.10.2016 tarihleri arasında, Dublin, İrlanda'da gerçekleşen "The 20th International Conference on Miniaturized Systems for Chemistry and Life Sciences" adlı konferansa katılıp, Üniversitemizdeki görevine geri dönecektir.

Bilgilerinize sunulur.

Saygılarımla.

BİLKENT ÜNİVERSİTESİ ANKARA 1984 REKTÖRLÜĞÜ

Prof. Dr. Abdullah ATALAR
Rektör

DÖ